[MO] double electron transitions above $_{74}$W M_{III} edge in x−ray absorption spectra

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Abstract

The x−ray absorption spectra have been measured near M_{III} edge of metallic W (Tungsten). Several features caused by multielectron transitions suggested on noble gases were detected on M_{III} in solid phase and analyzed by the use of the shake processes. The [3p4f], [3p5s], and [3p5p] transition onsets have been identified in W metal.

1. INTRODUCTION

Photoabsorption of atoms has been generally treated as a single−electron xcitation process. However, the existence of the multielectron excitation process, where the removal of a core electron by photoabsorption causes excitation of additional electrons in the same atoms, has been known in x−ray absorption spectra for a long time [1].

With the advent of synchrotron radiation facilities, this process has been studied extensively in various gases [2~7]. It was pointed out by Kodre and co−workers that for solid targets it is difficult to idntify weak transitions corresponding to multielectron excitation in x−ray absorption spectra. The reason is that in condensed matter, the oscillation due to the x−ray absorption fine structure masks small signals in the energy region where multiple electron excitation ([KL]) occurs.

The [KM], [L_xN] and [LO] transitions within the extended XAFS (EXAFS) oscillations, together with x−ray absorption near edge structure, have been recognized in crystalline samples [9,10] and the [KL] double− electron transition edges of Si, P, S, and Cl in compounds were recognized in x−ray absorption spectra by Filipponi *et al.* [11]. The understanding of the transition processes involved in multielectron excitations is very important to interpret XAFS [8~13]. These processes have therefore received a special attention in XAFS analysis. In this study, the x−ray absorption spectra have been measured above $_{74}$W M_{III} edge in $_{74}$W metal in order to elucidate the contribution of the multi−excitation to the multielectron processes in heavy elements.

2. EXPERIMENTAL

The x−ray absorption spectra for $_{74}$W were measured using the beam line 9.3.2 at the Advanced Light Source at a circular current of 200 ~ 400 mA for 8 hours. The harmonic content of the beam at this low energy was so great that the residual harmonic content contributed sufficient nonlinearities to cause significant noise. Therefore, it was necessary to minimize the harmonic content of the incoming beam. The radiation was detuned with a Si(111) double−crystal and the mirror to reduce the harmonic content. The calculated energy resolution (combined intrinsic crystal resolution and vertical angular divergence of the beam) was less than 1 eV at the energy of $_{74}$W $M-$edge. A high purity metal foil of $_{74}$W was used for the absorption experiment. The absorption was monitored by collecting the total current from the sample as a function of exciting energy. The incident intensity (Io) of the x−ray beam was recorded as the current from a 95% transparent aluminium mesh in the beampath. Spectra were recorded at room temperature over a 110 eV range with a step size of 0.5 eV as shown in Fig.1.

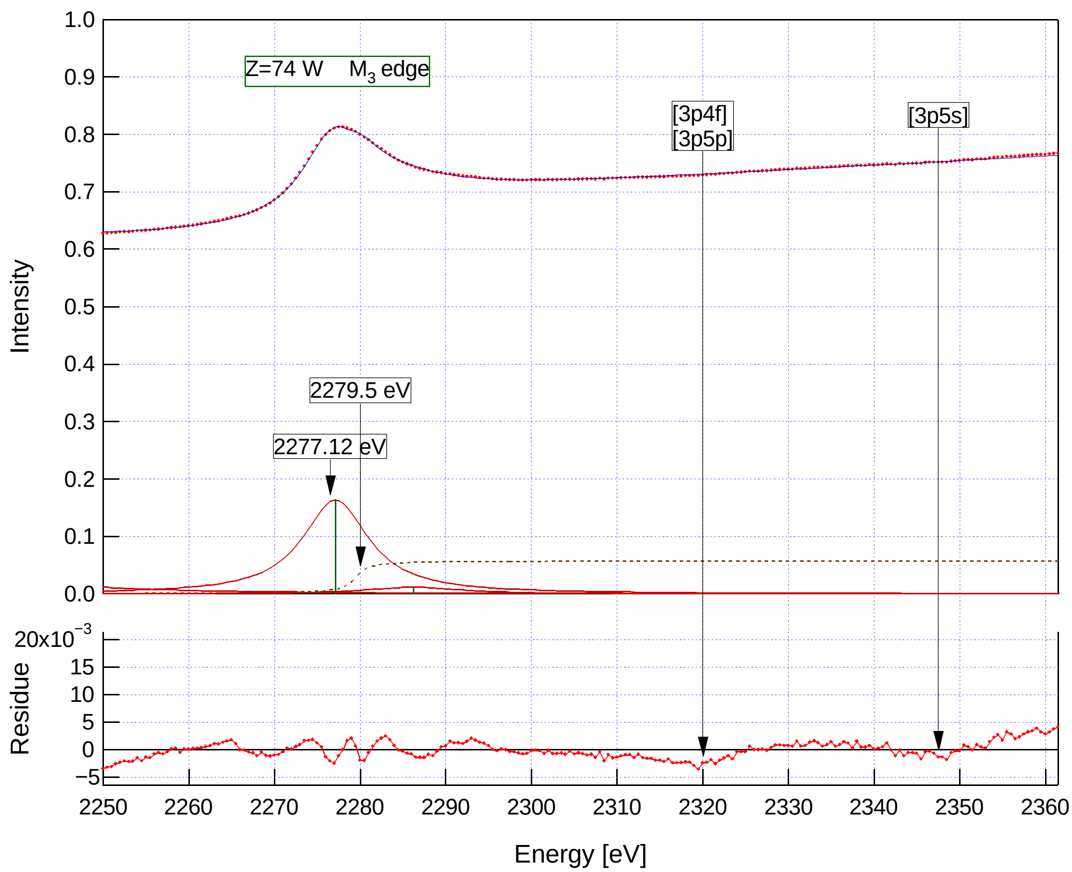

Figure 1. The x−ray absorption spectra above $_{74}$W−M_{III} edge. The arrows indicate the energy position predicted by the Z+1 approximation.

3. RESULTS & DISCUSSION

As shown in Fig.1, the evidence of the multielectron excitations above the $_{74}$W M_{III} edge can be obtained by subtracting the XAFS oscillations from the observed absorption spectra. The threshold onsets occurs at 40 eV and 80 eV which appear to be due to the multi−electron transition.

For all the edges studied below, we compare the position of the step to that predicted by the Z+1 approximation model [10]. This model gives 40 eV and 70 eV for the $N-$ and $O-$levels, respectively, using the x−ray atomic energy level [14] of $_{74}$W to calculate the energy of the second core hole. It is found that these values are consistent with [3p4f], [3p5s], and [3p5p] double electron transitions. These are in good agreement with the predictions of the Z+1 model as listed in Table 1.

Table 1. Electron configuration and energies of two−electron transitions for $_{74}W$ atom. The energies (ΔE) are given relative to the *M* edge(M_{III}) of $_{74}W$ atom.

Configuration	ΔE (eV)	
	Z+1	measured
[3p4f]	40.6	40
[3p5p]	45.6, 34.6	40
[3p5s]	82.8	68

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